Florida Department of Transportation Research

Load and Resistance Factors Design (LRFD) Resistance Factors for Tip Grouted Drilled Shafts

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Current Situation

Florida's sand and clay soils do not provide the best foundation from many structures. Therefore, deep foundations – often drilled shafts – are used to provide a solid foundation. A drilled shaft foundation is basically a drilled hole filled with steel-reinforced concrete. These piles are highly adaptable to both project and site, and their bearing capacity can be further enhanced by postgrouting, in which grout is injected beneath the pile after the concrete has set. Though postgrouting is widely used, no design methodologies or design parameters have been published. Although approximate methods exist, standard research-based design parameters are needed to better design postgrouting applications.

Research Objectives

University of South Florida researchers established Load and Resistance Factor Design (LRFD) resistance factors for postgrouted end bearing drilled shaft piles.

Project Activities

The researchers compiled data from 31 test drilled shafts from 17 projects for their analyses. Data per pile included shaft diameter, length, boring logs, grouting logs, and load test reports. These drilled shafts were used on sites in Florida and other states in the US, ranging in diameter from 3 to 12 feet and in length from 15 to 115 feet.

Load testing a drilled shaft piling involves exerting enormous pressures and observing the subtle movements of the drilled shaft.

The researchers compared the measured to the predicted end bearing capacity and computed soil resistance factors based on bias statistics. Their goal was to compare field measurements and end bearing capacity predictions to produce resistance factors that could be used to calculate the best predicted load capacity. The researchers evaluated the resistance factors for three different methods of estimating the grouted end bearing capacity: (1) based on the field effective pressure obtained from the tri-axis plots; (2) based on the maximum field pressure; and (3) based on the boring log calculated pressure. Predicted and measured end bearing capacities were compared for the three methods and for toe displacements ranging from 0.3% to 5% of pile shaft diameter. This produced a series of possible resistance factors for each pile. In the process, the researchers also developed graphing evaluation procedures that allow the determination of the effective pressure.

Without limiting the toe displacement, resistance factors were found to be higher for the effective pressure method and lowest for the boring log-calculated pressure method when no upper cap is placed to the end bearing. When the grouted end bearing is capped to the grout pressure and for a toe displacement of 1% of the shaft diameter, both methods (effective pressure and boring log-calculated pressure) resulted in the same resistance factor. The findings further recommend adoption of strict field quality control measures to support the use of the computed resistance factor.

Project Benefits

Improved design methods can lead to designs that better match expected performance, reducing construction time and helping assure that structures perform as intended.

For more information, please see www.fdot.gov/research/.